6 June 1969

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

PROJECTOR, STILL PICTURE

1. OBJECTIVE

This document provides test methods and techniques necessary to determine the technical performance and safety characteristics of still picture projectors as described in the Qualitative Materiel Requirements (QMR's), Small Development Requirements (SDR's), Technical Characteristics (TC's), and to determine the test item's suitability for service tests.

2. BACKGROUND

A requirement exists for a device to project still pictures. A still picture projector should be capable of projecting a reasonably accurate image from the still picture source. It is desirable to determine this accuracy, as well as other operating characteristics.

All still picture projectors are essentially similar. A light source shines through a transparent still picture (or reflects off an opaque picture), onto a projection lens. The lens system then focuses the image on a screen. Sophistications to this basic design include collimating lenses, reflecting light source enclosures and ventilating fans. Various types of mechanical devices hold and change the still picture source.

3. REQUIRED EQUIPMENT

a. Rules, for measuring various distances as specified in individual tests.

b. Test Charts:

1) Test Transparencies:

a) Resolution
b) Tangential Distortion
c) Transparency with uniform density of 2.0 or greater

2) Or obtain the following equipment to be used in producing the required test transparencies:

a) Reticles
b) Lens resolution test charts, as specified in MIL-STD-150A
c) High quality Camera and Filn

c. Screen, which has a flat white surface.

d. Microscope.

e. Photo-electric light meter, corrected with filters to approximate the spectral sensitivity of the eye.

f. Thermocouple, and associated equipment to measure temperature.

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g. Noise level meter, with bandpass filters and microphone.

h. A table capable of supporting the projector and inclining in all directions at any angle with the vertical.

i. Temperature and Humidity Chamber

j. Equipment and Facilities as specified in referenced MTP's.

4. REFERENCES

A. USATECOM Regulation 385-6, Safety Release.
B. USATECOM Regulation 700-1, Value Engineering.
C. USATECOM Regulation 705-4, Equipment Performance Report.
D. PH 3.28-1945, American Standard Specifications for Slidefilm Projectors. Reaffirmed 1957.
E. Z 38.7.5-1948, American Standard Methods of Testing Printing and Projection Equipment. 1948
F. PH 3.41, American Standard Practice for Slide and Slidefilm Projection.
G. PH 3.27-1949, American Standard Specifications for Lantern Slide Projectors. Reaffirmed 1957.
H. PH 3.16-1947, American Standard Method for Determining Resolving Power of Lenses for Projectors for 35 mm. Slidefilm and 2 x 2 Inch Slides. Reaffirmed 1959.
I. National Bureau of Standards Circular Number 533, Method for Determining Resolving Power of Photographic Lenses. 20 May 1953.
J. Jenkins and White, Fundamentals of Optics. 1957
K. Hardy and Perrin, The Principles of Optics. 1932
L. HEL-Standard S-1-63B, Maximum Noise Level for Army Materiel Command Equipment.
M. MIL-STD-810B, Environmental Test Methods.
N. MTP 10-2-500, Physical Characteristics.
O. MTP 10-2-501, Operator Training and Familiarization.
P. MTP 10-2-503, Surface Transportability (General Supplies and Equipment.)
Q. MTP 10-2-505, Human Factors Evaluation.
R. MTP 10-2-507, Maintenance Evaluation.
S. MTP 10-2-508, Safety.

5. SCOPE

5.1 SUMMARY

This MTP describes the following tests:

a. Preparation for Test - A determination of the physical condition of the test item upon arrival, its physical characteristics, and procedures of operator training and familiarization of the test item.

b. Resolution - An evaluation to quantitatively determine the test item's resolution capabilities, that is the ability of the projection system to project images containing fine detail.

c. Distortion - An evaluation to quantitatively determine the test item's ability to accurately project the geometry of test transparencies. Tests include radial and tangential distortion.

d. Screen Illumination - An evaluation to quantitatively determine the brightness of the projected image and the evenness of illumination of the projected image.

e. Transparency Temperature - An evaluation to quantitatively determine the temperature of a transparency while its image is being projected.

f. Projected Image Area Size - An evaluation to quantitatively determine the projected image area size for any projector-to-screen distance.

g. Noise - An evaluation to quantitatively determine the noise generated by the projector when operating.

h. Physical Stability - An evaluation to quantitatively determine the intrinsic mechanical stability of the projector.

i. Accelerated Wear - An evaluation to determine the projector wear characteristics under repetitive operation.

j. Environmental Tests - An evaluation to determine the capability of the test item to operate properly after exposure to extreme conditions of temperature and humidity.

k. Transportability - An evaluation to determine the capability of the test item to withstand the shock associated with handling and transportation.

l. Safety - An evaluation to determine whether the test item contains any hazards.

m. Maintainability and Reliability Evaluation - That portion of the test which is concerned with the following: verification and appraisal of failures; determination and appraisal of maintenance characteristics and requirements; appraisal of design-for-maintainability; appraisal of the maintenance test package; and, calculation of indicators which express the effects of the preceding aspects.

n. Human Factors Evaluation - An evaluation of the man-item relationship during operation and maintenance of the test item to include adequacy of the design and layout of controls and any operability design deficiencies.

o. Value Analysis - A study to determine whether the projector contains any unnecessary nonfunctional, costly, or nice-to-have features.

5.2 LIMITATIONS

The test methodology and techniques of this document relate to still picture (transparency) projectors. They do not specifically relate to overhead projectors, or vertical reflecting photogrammetric projectors. However, the methods and techniques are general in nature, and most apply directly. Notes are included in the text to indicate necessary departures from test methodology for some specific projectors.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Initial Inspection

Upon receipt of the test item at the test site, the test item shall be subject to the following procedures:

a. Visually inspect the test item package(s) and record the following:

1) Evidence of packaging damage or deterioration
2) Identification markings, including:

a) Name of contractor
b) Number and date of contract
c) Date of manufacture
d) Other markings pertaining to the test item

b. Weigh and measure the individual package(s) of the test item and its accessories and record the following:

1) For each shipping package:

a) Contents
b) Weight
c) Length, width, and height
d) Cubage

2) For entire test item:

a) Weight
b) Cubage

c. Unpack the test item; visually inspect it, and record the following where applicable:

1) Type and adequacy of packing material
2) Evidence of defects in:

a) Manufacturing
b) Material
c) Workmanship

3) Evidence of damage
4) Evidence of wear

NOTE: Make use of photographs, diagrams and narration to indicate the condition of the test item.

d. Presence of instruction plates, if applicable, including:

1) Identification, name and serial number
2) Caution instructions
3) Service instructions

e. Existence of shortages

6.1.2 Physical Characteristics

Determine and record physical characteristics of the projector as described in the applicable sections of MTP 10-2-500 and the following:

a. Test item nomenclature and serial number
b. Dimensions for individual projector components and complete projector:

1) Weight
2) Length, height, and width

c. Electrical characteristics as specified in the equipment, including:

1) Voltage
2) Current
3) Wattage

d. Distinguishing characteristics:

1) Type of projector (by type of image source, i.e. slide, filmstrip, overhead, opaque, etc.).
2) Size of projector (by size of image source used).
3) Type of image source advance mechanism (i.e. manual, semi-automatic, automatic, remote control).

NOTE: The image source is called the transparency throughout the document, for convenience. For those projectors which do not project through transparencies, use the usual image source.

4) Type of focusing (i.e. manual, automatic, remote control).
5) Other distinguishing characteristics:

a) F-number of each lens supplied with projector (if variable, include all numbers).
b) Focal length of each lens supplied with projector.
c) Other.

6.1.3 Operator Training and Familiarization

Test personnel shall receive training and familiarization in accordance with applicable sections of MTP 10-2-501 and the following:

a. Test personnel shall receive familiarization in the following areas:

1) Test objectives
2) Projector operation and capabilities
3) Projector maintenance
4) Safety precautions.

b. The draft technical manuals will be made available for study. Record the adequacy of the manuals for training purposes.
c. Record any unusual difficulties.

6.1.4 Preparation

Perform the following:

a. Remove all protective material and preservatives.
b. Lubricate all components as required by the applicable maintenance instructions or lubrication orders.

6.2 TEST CONDUCT

NOTE: All equipment failures shall be reported in accordance with USATECOM Regulation 705-4.

6.2.1 Resolution

6.2.1.1 Preparation for Test

a. Obtain a test transparency or prepare one as follows:

1) Fasten high contrast resolution test charts along the diagonals of a test target as follows:

NOTE: If possible, obtain resolution test charts with markers which suffice for reticles so that the test transparencies can be used for Radial Distortion Test.

a) Place a target in the center; place all other targets symmetric to the center.
b) Space the targets so that there is a constant angular separation of $2\frac{1}{2}°$ between centers of targets.
c) Orient the targets so that one set of lines is in the radial direction, and the other set of lines is in the tangential direction.

2) Photograph the test target with a high quality camera, so that:

a) The targets fill the field.
b) The object distance is such that the scale numbers on the chart are correct (or, at least, the reduction ratio is known).

3) Process the transparency so that the dark lines of the test pattern have a photographic density of at least 2.0 greater than the density of the background.
4) Examine the finished transparency under a microscope to be certain that the transparency exhibits considerably more resolution than the expected resolution of the projector under test.

b. Project the test transparency as follows:

1) Place a flat, white screen at a distance T from the projector,

perpendicular to the optical axis.
2) Project the test transparency upon the screen.
3) Adjust T for easy viewing of each resolution chart.
4) Focus the central target for maximum resolution.

6.2.1.2 Test Conduct

a. Determine and record the number of radial and tangential lines/mm. resolved on each target.
b. Measure and record throw distance T.

6.2.2 Distortion

6.2.2.1 Tangential Distortion

6.2.2.1.1 Preparation for Test - Perform the following:

a. Obtain a test transparency for tangential distortion or prepare one as follows:

1) Place reticles in pairs about the diagonals of the target plane as follows:

a) Place a reticle in the center of the target. Place all reticle pairs symmetric to it.
b) Each reticle pair shall lie on a line perpendicular to the diagonal.
c) The midpoint of the line which separates the two reticles in each pair shall be on the diagonal.
d) The distance of separation of the two reticles in each pair (along the line perpendicular to the diagonal) shall be 1, a constant value for all pairs of reticles.
e) The distance measured along the diagonal from one reticle pair shall subtend an angle of 2½° as measured from the camera.
f) The distance 1 shall subtend an angle of less than 5°, as measured from the lens of the camera.

2) Photograph the test target with a high quality camera so that the reticles fill the field.
3) Process the test transparency and ascertain that the distortion on the test transparency is very small compared with the expected distortion of the projector.

NOTE: 1. Determine the distortion on the test transparencies using the procedure outlined in Appendix A.

2. If the distortion on the test transparency is too great, the positions of the reticles on the test target can be altered to compensate for the camera distortion.

b. Project the test transparency as follows:

1) Place a flat, white screen at a distance T from the projector, perpendicular to the optical axis.
2) Project the test transparency upon the screen and focus the image.
3) Adjust T so that the long dimension of the projected image is 40 inches.

6.2.2.1.2 Test Conduct - Perform the following:

a. Measure the throw T, the distance from the screen to the front of the projector lens along the optical axis.
b. Measure the distance h, where h is the distance between reticles in a pair on the test transparency, measured perpendicular to the diagonal.
c. Measure the distance H, where H is the distance between reticles in a pair on the screen, measured perpendicular to the diagonal.
d. Measure U, the distance from center to each of the four nearest reticles along the diagonals (on the screen).

6.2.2.2 Radial Distortion

6.2.2.2.1 Preparation for Test - Perform the following:

a. Obtain a test transparency or use the one prepared in paragraph 6.2.1.1.
b. Project the test transparency as follows:

1) Place a flat, white screen at a distance T from the projector, perpendicular to the optical axis.
2) Project the test transparency upon the screen.
3) Adjust T for easy viewing of each resolution chart. Focus the projected image.

6.2.2.2.2 Test Conduct - Perform the following:

a. Measure on the screen the distance of each reticle from center.
b. Measure the throw T, where T is measured from the front of the projector lens to the screen, along the optical axis.

6.2.3 Screen Illumination

6.2.3.1 Preparation for Test

a. Ready the projector for operation.
b. Project a transparency on a screen placed perpendicular to the optical axis which is at a distance from the projector so that the long dimension of the projected image is 40".
c. In some manner outline the projected image area on the screen for future reference. Remove the transparency.
d. Divide the projected image area into 12 equal areas, as in Figure 1.

1	2	3	4
5	6	7	8
9	10	11	12

Figure 1. Projected Image Area

6.2.3.2 Light Output

a. Measure the direct (not reflected) illumination at the center of each square in the plane of the screen.

NOTE: 1. This measurement can be made with a photo-electric light meter corrected with filters to approximate the spectral sensitivity of the human eye. Other methods exist; the method used is not critical. While making this measurement, all lenses shall be clean and in proper adjustment.
2. For those projectors which project images from opaque materials, a transparency cannot be removed. Instead, use a glossy white sheet of paper for brightest image projection.

b. Note bands or patches of uneven light distribution.
c. Measure and record the short dimension of the projected image.

6.2.3.3 Corner to Center Illumination Ratio

a. Measure the illumination (direct) in the center of the projected image area. (See NOTE 1 and 2 of paragraph 6.2.3.2).
b. Measure the illumination (direct) in each corner of the projected image area. Measure at a point 2" from the side edge and 2" from the top or bottom edge.

6.2.4 Transparency Temperature

a. Obtain a test transparency of uniform density (2.0 or greater).
b. Cement a thermocouple to the emulsion side of the slide, in the center.
c. Operate the projector continuously until it reaches thermal equilibrium.

NOTE: The ambient temperature shall be maintained at 70°F.

d. Insert the test transparency into projection position, with the emulsion side facing the screen.

e. Allow the test transparency to remain in projection position until it reaches thermal equilibrium.

f. Measure and record the temperature of the test transparency. Remove the test transparency.

g. Continuously operate the projector for two hours.

h. Using a thermocouple determine the hottest spot of the projector housing (not the fan exhaust pot on the top cover of the lamp house) and measure and record this temperature.

i. At the completion of step h repeat the procedures of steps d, e, and f.

6.2.5 Projected Image Area Size

a. Select a test transparency and record its size, e.g. a 23 x 34 mm. slide.

NOTE: The size which must be measured and recorded is the transparency, not a cardboard border. It is desirable to specify the transparency size indirectly. For example, the statement that "the test transparency is a 35 mm. double-frame slide" completely characterizes the test transparency size (23 x 34 mm.).

b. Insert the test transparency into the projector, and project an image upon a screen perpendicular to the optical axis, at a distance T away from the projector so that the long dimension of the projected image is 40 inches. Record T.

c. Measure the short dimension of the projected image.

d. Repeat steps b and c for each lens supplied with the projector.

6.2.6 Noise

Evaluate the noise level of the projector subjectively. If there is sufficient noise interference, measure the degree of noise by instrumentation (i.e. as described in references 4.L, HEL-Standard S-1-63B).

NOTE: The noise level should not exceed the criteria of HEL Standard S-1-63B, Table 3, Page 10, Maximum Steady-State Noise Level for Non-Electrically Aided Person to Person Communication.

6.2.7 Physical Stability

6.2.7.1 Preparations for Test

Place the projector on a table capable of tilting in all directions at any angle with the vertical.

6.2.7.2 Test Conduct

a. Tilt the table in any given direction until the projector begins to slide or tip over. Record the table angle.

b. Repeat step a for all directions.

c. While operating the projector, tilt it in any given direction until it no longer operates correctly. Record the angle.

d. Repeat step c for all directions.

e. Operate the horizontal tilt control on the projector and record the following:

1) Number of hands required to adjust tilt.
2) Maximum tilt.
3) Ability to select desired tilt, i.e. to place image where desired.
4) Ease of operating tilt control.

f. Determine and record whether fan motor vibrations visibly affect the projected image.

6.2.8 Accelerated Wear

a. Set up projector for operation.

b. Start a run of 50,000 transparencies through the film gate, at a rate no greater than two transparencies per second.

c. Operate the slide changer mechanism continuously, replacing bulbs as they burn out, and removing slides as they jam.

d. Record all failures including:

1) Type of failure
2) Number of transparencies projected at time of failure

e. Record all jamming of slides.

f. Record all damage done to slides.

g. At conclusion of 50,000 slide run, disassemble the slide projector and inspect the parts for:

1) Excessive wear
2) Damage
3) Proper mechanical fit and tolerances
4) Damage to wiring

6.2.9 Environmental Tests

a. Cycle the projector in its transit case through the temperature and humidity cycle specified by the QMR's, SDR's, or other developmental requirements.

b. Remove the projector from its transit case, and wipe off any excess moisture.

c. Perform an operational test as follows:

1) Allow the projector to return to room temperature and humidity.
2) Inspect the projector for corrosion, mechanical binding, or mechanical looseness.
3) Operate the projector under normal conditions to determine

if there has been any change in its operating characteristics.

6.2.10 Transportability

a. Determine the transportability of the test item as described in the applicable sections of MTP 10-2-503.

b. Upon completion of each procedure performed, the test item shall be operated under normal conditions to determine and record any changes in its operating characteristics and evidence of mechanical binding or looseness.

6.2.11 Safety

Determine the test item safety hazards as described in the applicable procedures of MTP 10-2-508 and the following:

a. Look for and record any evidences of sharp, protruding pieces from the projector.

b. Note and record any high voltages or currents that might be used for the camera or its accessories, which:

1) Are insufficiently shielded
2) Do not contain caution plates

6.2.12 Maintainability and Reliability Evaluation

Evaluate the maintenance-related factors of the test item as described in MTP 10-2-507 with emphasis on the following:

a. Organizational (O), Direct Support (F), and General Support (H) Maintenance Requirements.
b. Operator through General Support Maintenance Literature.
c. Repair parts.
d. Tools.
e. Test and handling equipment.
f. Calibration and maintenance facilities.
g. Personnel skill requirements.
h. Maintainability.
i. Reliability.
j. Availability.

6.2.13 Human Factors Evaluation

a. Evaluate the man-item relationship during normal projector use as described in the applicable sections of MTP 10-2-505 and the following:

1) Throughout all testing, observe and record the user's comfort, ease, capability to get the desired projection size, and operate the transparency advance mechanism.
2) Observe and record any difficulties, such as excessive pressure, awkwardness or binding encountered in the operation of the controls and transparency advance mechanism.

3) Observe and record the relative ease of making the projector operational.

b. Compare the test item with a standard or control projector as to operational characteristics.

NOTE: Comparisons between the characteristics of the test and standard projectors will be considered in determining the suitability of the test projector. Where standards do not exist, suitability of the projectors will be based upon the observations and comments of the test supervisory personnel.

6.2.14 Value Analysis

Determine whether the item has any nonfunctional, costly, or nice-to-have features as stated in USATECOM Regulation 700-1 by performing the following:

a. During operation and maintenance of the projector, observations will be made to determine whether the projector incorporates any features that could be eliminated without compromising their performance, reliability, durability, or safety.

b. During the conduct of the test, users will be informally questioned regarding any features of the projector that may be eliminated without decreasing the functional value of the projector. All user comments regarding value analysis will be recorded in the daily log.

c. The test team members will study the projector during use and will comment separately in the daily log on elimination of unnecessary features, using their experience and background with respect to value analysis.

6.3 TEST DATA

6.3.1 Preparation for Test

6.3.1.1 Initial Inspection

Record the following:

a. Evidence of packaging damage or deterioration
b. Identification markings:

1) Name of contractor
2) Number and date of contract
3) Date of manufacture
4) Other pertinent markings

c. For each shipping package:

1) Contents
2) Weight, in pounds
3) Overall dimensions, in feet and inches of:

a) Length
b) Width
c) Height

4) Cubage, in ft^3.

d. For the entire test item:

1) Weight, in pounds
2) Cubage, in ft^3.

e. Type and adequacy of packing material
f. Defects in:

1) Material
2) Construction
3) Workmanship

g. Evidence of damage
h. Evidence of wear
i. Presence of:

1) Identification plate
2) Caution instruction plate
3) Service instruction plate

j. Shortages

6.3.1.2 Physical Characteristics

Record data required by MTP 10-2-500 and the following:

a. For individual test item components and complete test item, as applicable:

1) Nomenclature
2) Serial Number
3) Weight in pounds
4) Length, height and width, in feet and inches

b. Electrical Characteristics:

1) Voltage, in volts
2) Current, in amperes
3) Wattage, watts

c. Distinguishing Characteristics.

1) Type of projector (by type of image source being used, i.e. slide, filmstrip, overhead, opaque, etc.).
2) Size of projector (by size of image source used).

3) Type of image source advance mechanism (i.e. manual, semi-automatic, automatic, remote control).
4) Type of focusing (i.e. manual, automatic, remote control).
5) Other distinguishing characteristics:

a) F-number (max) of each lens supplied with the projector
b) Focal length of each lens supplied with the projector
c) Other

6.3.1.3 Operator Training and Familiarization

Record data required by MTP 10-2-501 and the following:

a. Adequacy of the draft technical manuals
b. Difficulties encountered during training and familiarization

6.3.2 Test Conduct

6.3.2.1 Resolution

Record the following:

a. Number of lines/mm:

1) Radial
2) Tangential

b. Throw distance T in inches

6.3.2.2 Distortion

6.3.2.2.1 Tangential Distortion -

Record the following:

a. The throw T, the distance from the screen to the front of the projector lens along the optical axis (in inches).
b. The distance h, where h is the distance between reticles in a pair on the test transparency, measured perpendicular to the diagonal (in inches).
c. The distance H, where H is the distance between reticles in a pair on the screen, measured perpendicular to the diagonal (in inches).
d. The distance U where H is the distance from center to each of the four nearest reticles along the diagonals (on the screen), in inches.

6.3.2.2.2 Radial Distortion -

Record the following:

a. The distance (in inches) from center of each reticle (on the screen).
b. The Throw T.

6.3.2.3 Screen Illumination

6.3.2.3.1 Light Output -

Record the following:

a. The direct (not reflected) illumination at the center of each square in the plane of the screen, in foot candles.
b. Bands or patches of uneven light distribution.
c. The short dimension of the projected image, in inches.

6.3.2.3.2 Corner to Center Illumination Ratio -

Record the following:

a. The direct (not reflected) illumination in the center of the projected image area, in foot-candles.
b. The direct (not reflected) illumination in each corner of the projected image area, in foot-candles.

6.3.2.4 Transparency Temperature

Record the following

a. The temperature of the test transparency, taken as soon as the projector has reached thermal equilibrium, in degrees Fahrenheit.
b. The temperature of the test transparency, taken after the projector has run continuously for 2 hours, in degrees Fahrenheit.
c. The highest temperature of the projector housing in degrees Fahrenheit.

6.3.2.5 Projected Image Area Size

Record the following for each lens supplied:

a. Lens used
b. Size of the test transparency.
c. The distance T, the distance from the projector to the screen, measured in inches.
d. The short dimension of the projected image, in inches.

6.3.2.6 Noise

Record the following for each band, if applicable

a. Intensity of noise in db.
b. Band measured in frequency range

6.3.2.7 Physical Stability

Record the following:

a. For sliding or tipping of test item:

1) Angle of table tilt in degrees
2) Direction of tilt with respect to test item

b. For test item failure to function while tilted:

1) Angle of table tilt in degrees
2) Direction of tilt with respect to test item

c. Record the following data for the horizontal tilt mechanism:

1) Number of hands required to adjust tilt.
2) Maximum tilt, in degrees
3) Ability to select desired tilt
4) Ease of operating tilt control

d. Record whether fan motor vibrations visibly affect the projected image.

6.3.2.8 Accelerated Wear

Record the following:

a. Projector failures

1) Type of failure
2) Number of transparencies projected at time of failure

b. Jamming of transparencies
c. Damage to transparencies
d. Projector parts:

1) Excessive wear
2) Damage to projector parts
3) Mechanical fit and tolerances
4) Damage to wiring

6.3.2.9 Environmental Tests

Record the following:

a. Evidences of corrosion, mechanical binding, or mechanical looseness.
b. Changes in operating characteristics.

6.3.2.10 Transportability

Record the following:

a. Data collected as described in the applicable section of

MTP 10-2-503 and the following:

b. Changes in operating characteristics

6.3.2.11 Safety

Record the following:

a. Data collected as described in the applicable section of MTP 10-2-508.

b. Evidences of sharp protruding pieces from projector.

c. Evidences of high voltages or currents used in camera or associated equipment.

6.3.2.12 Maintainability and Reliability Evaluation

Record data collected as described in the applicable section of MTP 10-2-507

6.3.2.13 Human Factors Evaluation

Record data collected as described in the applicable section of MTP 10-2-505 and the following:

a. User's comfort, ease, capability to get the desired projection size, and operate the transparency advance mechanism.

b. Difficulties, such as excessive pressure, awkwardness or binding encountered in the operation of the controls and transparency advance mechanism.

c. The relative ease of making the projector operational.

d. Results of comparison with standard projector.

6.3.2.14 Value Analysis

Record the following:

a. Whether the projector incorporates any non-functional, costly, or nice-to-have features that could be eliminated without compromising the performance, reliability, durability or safety.

b. The user's comments in the log.

c. The test team's comments.

6.4 DATA REDUCTION AND PRESENTATION

a. A preliminary report shall be submitted in accordance with USATECOM Regulation 385-6, based on the data collected related to Safety.

b. Data shall be summarized to reveal significant discrepancies between the specified requirements and the observed performance of the test item and be presented in chart, tabular, or graphic form, as appropriate, presented as described in the applicable sections of reference MTP's and as follows:

6.4.1 Resolution

a. Average the radial and tangential test chart resolutions for each angular position.

b. Graph the averages obtained vs. angular position (angle from optical axis), using Table I as a guide.

6.4.2 Distortion

6.4.2.1 Tangential Distortion

a. Average the H's (the distance between reticles in a pair on the screen) of the four reticle pairs nearest center to obtain $\overline{H}$.

b. Calculate the magnification factor M, using the following formula:

$$M = \frac{\overline{H}}{h}$$

where h is the distance between reticles in each pair along the line perpendicular to the diagonal on the transparency.

c. Average the U's (the distance from center along the diagonals on the screen of the four reticle pairs nearest center) to obtain $\overline{U}$.

d. Each reticle pair is connected by a line segment, the midpoint of which subtends an angle n θ with the optical axis (n is the number of the reticle pair, counting along the diagonal from center). Calculate θ by using the following formula:

$$\theta = \tan^{-1}\left(\frac{\pi}{T}\right)$$

where T is the throw.

e. Calculate the displacement at each reticle pair as follows:

(displacement) = Mh - (measured distance of separation)

f. For each angular position (nθ) of the reticle pairs, average the displacements to obtain $\overline{d}$.

g. Graph the average fractional displacement vs angular position, where average fractional displacement = $\frac{\overline{d}}{Mh}$.

6.4.2.2 Radial Distortion

a. Average the distance measurements (made on the screen) from the center to each of the four adjacent reticles, to obtain $\overline{P}$.

b. Calculate the magnification factor M, using the following formula:

$$M = \frac{\overline{P}}{p}$$

where p is the distance on the test transparency from center to each of the four adjacent reticles.

c. Each reticle subtends an angle nθ with the optical axis (n is the number of the reticle, counting from center). Calculate using the following formula:

TABLE I. RESOLVING POWER AS A FUNCTION OF f-NUMBER AND ANGLE FROM OPTICAL AXIS

			RESOLVING POWER									
			TANGENTIAL					RADIAL				
LENS	EFL	f-number	0°	5°	10°	15°	20°	0°	5°	10°	15°	20°
A	50 mm	2.0										
		2.8										
		3.5										
		4.0										
		5.6										
		8.0										
		11.0										
		16.0										
		22.0										
		32.0										
B	75 mm	2.0										
		2.8										
		3.5										
		4.0										
		5.6										
		8.0										
		11.0										
		16.0										
		22.0										
		32.0										

$$\theta = \tan^{-1} \frac{\bar{P}}{T}$$

where T is the throw (the distance from projector to screen).

d. Calculate the displacement for each reticle:

(displacement) = nMp - (measured distance on screen from center),

where n is the number of each reticle, counting from center.

e. For each angular position ($n\theta$) of the reticles, average the displacements to obtain $\bar{d}$.

f. Graph the fractional displacements vs. angular position, where fractional displacement is given by:

$$\frac{\bar{d}}{nMp}$$

6.4.3 Light Output

a. Average the twelve center of square illumination measurements.

b. Multiply this average center of square illumination (in foot candles) by the image area (in square feet) to obtain light output in lumens.

6.4.4 Corner to Center Illumination

a. Average the corner illuminations to obtain average corner illumination.

b. Divide average corner illumination by center illumination to obtain corner to center illumination ratio.

6.4.5 Projected Image Area Size

The projected image area is proportional to T^2. Consequently, it is desirable to find the proportionality constant C, so that an image area size may be predicted for arbitrary T.

a. Calculate the area A_{test} of the projected image obtained in the test section, using the following formula:

A_{test} = (40) (short dimension of projected image, in inches)

b. Calculate C_{test} as follows:

$$C_{test} = \frac{A_{test}}{T^2}$$

where A is in in^2 and T is in in.

NOTE: The constant C_{test} is valid only for the lens and transparency size being tested. Each individual lens must be tested through

the entire procedure to find its proportionality constant. Fortunately, the method for finding C for an arbitrary transparency size (but with the same test lens) is less tedious:

$$C = \frac{C_{test} A}{A_{test}}$$

where A is the area of the arbitrary transparency in in^2.

c. To predict image size for arbitrary T, use the following formula:

$$A = CT^2$$

6.4.6 Noise

If band measurements were taken, perform the following:

a. Average the three measurements for each band.
b. Compute the Articulation index using the formula below:

$$A = 0.896 - 0.00167 (B_1 + B_2 + B_3 + ... + B_8)$$

A = articulation index

B_i = Long average intensity per cycle of the noise level in db above a 10^{-16} watt/cm^2 in the i th band (bands 1-8 are listed in HEL-Standard S-1-63B)

NOTE: Long average intensity is equal to one half the average observed intensity in each band.

APPENDIX A

METHOD OF DETERMINING TRANSPARENCY DISTORTION

a. Determine the reduction ratio M:

$$M = \frac{D}{EFL} - 1$$

where: D = the object distance
EFL = the equivalent focal length

b. Determine radial distortion as follows:

1) Calculate the distance from center where the test reticles should appear on the image, using the following formula:

$$\text{(distance on image from center)} = \frac{\text{(distance on target from center)}}{M}$$

2) Measure the distance from center (of each reticle) on the image, using a traveling microscope (comparator).
3) Calculate the amount of displacement of where reticle image is, and where reticle image should be, by using the following formula:

(displacement of reticle image) = (calculated distance from center) - (measured distance from center)

4) Graph the displacement vs. angle from optical axis where the vertex of the angle is at the lens. (Recall the reticles were positioned every 2½ degrees along the diagonal).

c. Determine tangential distortion as follows:

1) Calculate the distance of separation of reticles on image for each reticle pair, using the following formula:

$$\text{(distance of separation on image)} = \frac{\text{(distance of separation on target)}}{M}$$

2) Measure the distance of separation of reticles on the test image, using a traveling microscope.
3) Calculate the amount of displacement, as follows:

(displacement) = (calculated distance of separation) - (measured distance of separation)

4) Graph the displacement vs. angle from optical axis where the vertex of the angle is at the lens. (Recall the reticle pairs were positioned every 2½ degrees along the diagonal on the target).